NNI/NSET/NNCO	YEAR ONE	GPRA, WASHINGTON

This card is a description of your child's development at this time

A (T) indicates the developmental level of your child at this time.

		REPORTING PERIODS						REPORTING PERIODS			
THINKING THROUGH PROBLEMS	works out solutions	T				BEHAVIOR IN GROUP SITUATIONS	participates with confidence and assurance	T			
	is dependent on help						usually follows others				
	is easily discouraged						participates very little				
SPEAKING SITUATIONS	expresses ideas and feelings freely					CONSIDERATION FOR OTHERS	shows thoughtfulness				
	is growing in use of sentences and vocabulary	T					usually recognizes the rights of others	T			
	seldom takes part in conversation						shows little concern for others				
LISTENING SITUATIONS	listens attentively	T				RESPONSE TO MEETING NEW SITUATIONS	adjusts quickly and easily				
	listens when encouraged						accepts new situations with reasonable ease	T			
	listens with difficulty						becomes upset				
FOLLOWING DIRECTIONS	is reasonably accurate	T				RESPONSE TO [illegible]	shows respect of group and school	T			
	needs considerable help						cooperates when encouraged				
WORK HABITS	works efficiently						disregards group decisions				
	shows initiative and originality	T				[illegible] CORRECTION	accepts and tries to improve	T			
	needs help with planning and following through						needs help in accepting corrections				
	is easily distracted					SHOWS INTEREST IN	Research	T			
HANDLING WORK MATERIALS	is skillful in handling materials	T					Grand Challenges	T			
	is having difficulty in handling materials						Infrastructure	T			
	is learning to handle materials						Centers/Network	T			
INTERAGENCY	is well coordinated						Technology Transition	T			
	is developing coordination	T					Societal Impact	T			
	is poorly coordinated						Education	T			
GROWTH IN INDEPENDENCE	assumes responsibility						International	T			
	tries to work independently	T				Date	CONFERENCE REPORT ☐ YES ☐ NO				
	needs much help and assurance										

nano.gov

Naval/Military Applications of Nanotechnology

Impact of Nanotechnology on the Marketplace

Naval-Industry R&D Partnership Conference

3 August 2004

Dr. James S. Murday
Head, Chemistry Division, Naval Research Laboratory
Executive Secretary, Nanoscale Science, Engineering and Technology Committee (NSET)

Anticipated Impact of Nanoscale S&T
Selected Examples

Structural Materials – high performance platforms, weapons, fire resistance
- Composite - strength to weight, electrical conductivity, permeability
- Metal alloys / precipitates
- Ceramics – optical transparency, superplasticity

Life Cycle Cost
- Affordable manufacturing processes – self assembly
- Reduced failure mechanisms

Energy Conversion / Storage – fuel cell, battery, high energy laser
- Nanocrystalline ceramic laser substrates
- Solar energy conversion
- Fuel cell catalyst / separation membranes
- Battery
- New explosives / propellants

Information Technology Devices
- Higher density, speed Logic
- Non-volatile DRAM

Medicine/Health
- Cancer treatment
- Prosthetics

"Nano Inside" – enable $1T market worldwide by 2020

Enhanced warfighting capabilities

- **Higher performance information technology**
  Terabit/cm^2 memory, near terahertz logic, non-volatile MRAM,…
- **Persistent, distributed sensing**
  Microfabricated sensory suites, local information processing, low power operation,….
- **Autonomous, uninhabited vehicles**
  Local command/control; miniaturization to reduce payload; increased endurance and range;…
- **Virtual/Augmented reality training**
  Full sensory – oral, visual, tactile; tailored to individual learning modes; ….
- **Individual Warfighter technologies**
  Miniaturization of IT; power supplies; active camouflage;….
- **Chem-bio warfare defense**
  Improved detection sensitivity and selectivity; decontamination; protection; therapeutics;…
- **High performance platforms and weapons**
  Stealth over multiple spectral bands; higher strength, light-weight materials and structures; reduced maintenance,…
- **Energy and energetic materials**
  Fast release explosives; insensitive munitions; slow release propellants,…
- **Medicine / heath / casualty care**
  Individual status monitors; better sanitary conditions (water, food); wound dressings; prosthetic devices; …

Defense Nanotechnology Research and Development Programs
Report to Congress, April 2004

DoD Nanoscience Funding Summary

	FY01		FY02		FY03		FY04 (est)		FY05 (req)	
	6.1	6.2/6.3	6.1	6.2/6.3	6.1	6.2/6.3	6.1	6.2/6.3	6.1	6.2/6.3
Air Force	5	3	11	9	9	7	29	7	8	
Army	7	8	18	5	24	15	26	9	25	8
Navy	20	3	38	2	34	1	40	1	40	1
DARPA	34	20	48	66	84	120	65	138	66	98
DDRE	24	2	26	2	28	0	0	0	0	0
Total	153		225		322		315		276	

FY2004 Naval Investment in Nanotechnology (~$M)

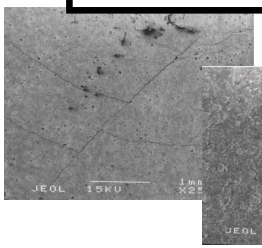
	6.1	6.2/6.3
Nanomaterials		
Electrical Power and Energy		
Thermoelectric, photoelectric	2.5	
Battery, fuel cell	3.5	
Structural and Functional Materials	5.5	0.5
Environmental	2	
Nano-Electronics, -Photonics, - Magnetics		
Electronics	10	0.5
Photonics	2.5	
Magnetics	3	
Nanobiotechnology	5.5	
Cross cutting	6	
Total	40	1

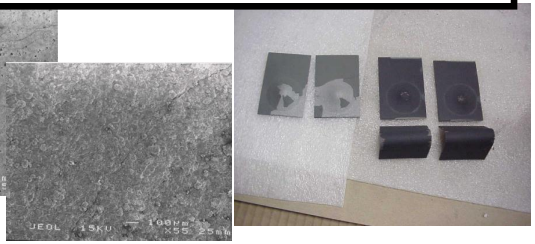
Advanced Nanometer Coatings for Low to Zero Maintenance Naval Applications

With thermal spray coatings and nanomaterial processing/ development research investment results as a foundation

Develop fundamental understanding of material processes to produce uniform coatings over complex curved surfaces

New coatings with unprecedented fracture & wear resistance and hardness





University Industry partnerships established for manufacturing development

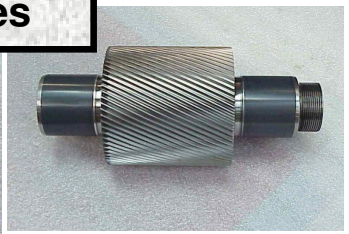
University Industry Navy Shipyard partnerships established for evaluations of new coatings in the marine environment

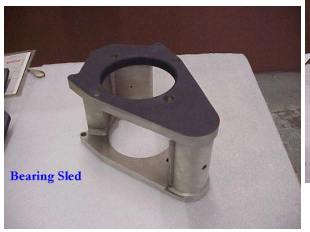
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003

Parts qualification continues

First nanostructured coating qualified for fleet use- Large ship A/C unit reduction gear bearing surfaces

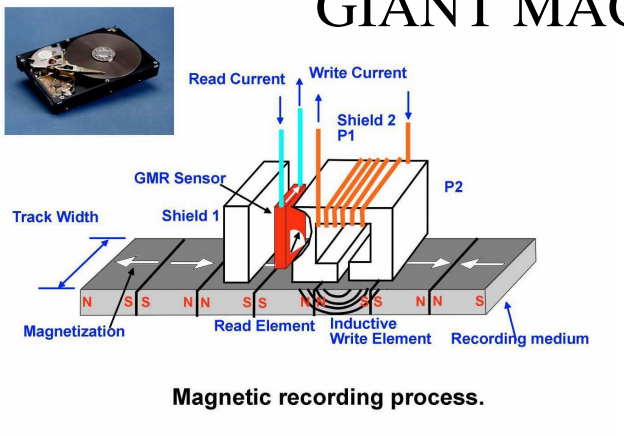
>$100M/yr Maintenance Cost Avoidance





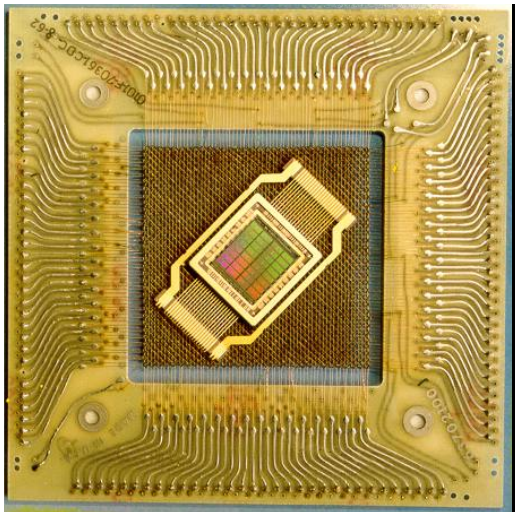
EVOLVING SUCCESS STORY:

GIANT MAGNETO RESISTANCE NON-VOLATILE MEMORIES

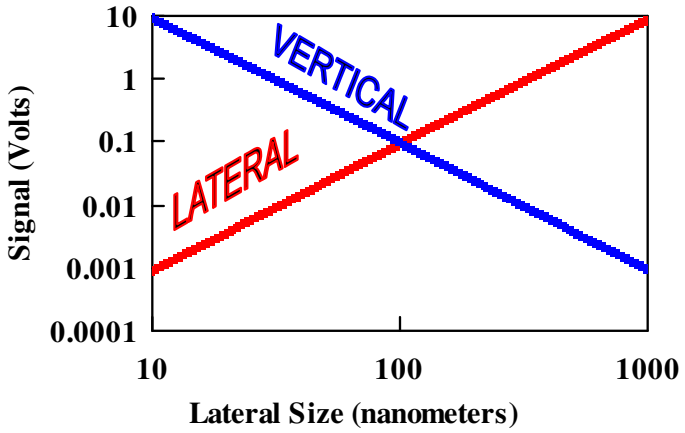


Magnetic recording process.

1998: IBM read head extends disk storage from 1 to 20 Gbits.

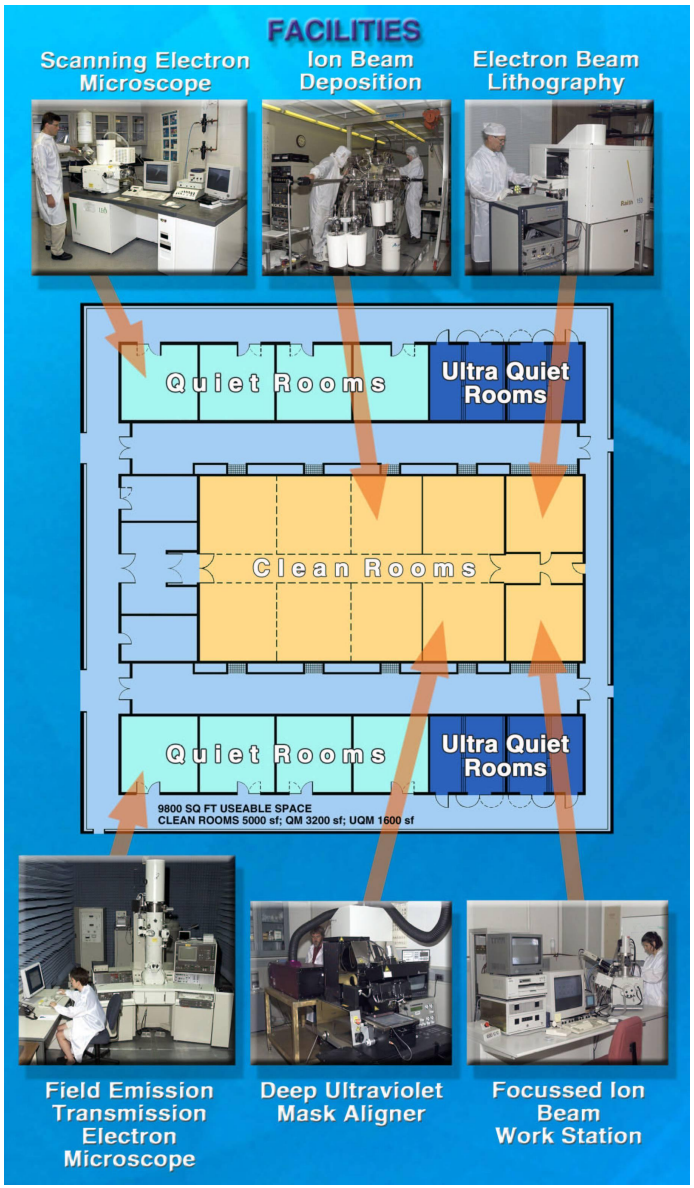


2004: Motorola 4Mbit GMR memory chip with ~10 ns access time.



2010: 10 Gbit GMR memory chip. Based on vertical GMR devices (Prinz, NRL)

NRL Nanoscience Institute
Facility and Program



- **Nanoassembly**
  - Nanofilaments: Interactions, Manipulation and Assembly
  - Chemical Assembly of Multifunctional Electronics
  - Directed Self-Assembly of Biologically-Based Nanostructures
  - Template-Directed Molecular Imprinting
  - Chemical Templates for Nanocluster Assembly
- **Nano-optics**
  - Photonic Bandgap Materials
  - Org. and Bio. Conjugated Luminescent Quantum Dots
  - Organic Light Emitting Materials & Devices
  - Nanoscale-Enhanced Processes in a Quantum Dot Structures
- **Nanochemistry**
  - Functionalized Dendrimeric Materials
  - Polymers and Supramolecules for Devices
- **Nanoelectronics**
  - Coherence, Correlation and Control in Nanostructures
  - Neural-Electronic Interfaces
- **Nanomechanics**
  - Nano-Elastic Dynamics
- **Collaborations**
  - Developing with universities, NSWC Indian Head, ARL Adelphi, NAVAIR

Dr. Gary Prinz, NRL Code 1100

http://nanoscience.nrl.navy.mil/

Preliminary Recommendations for Navy Nanotechnology Investment

- Sustain the 6.1 program in nanoscience,

  Revise the investment balance as new opportunities evolve.
- Work with the CARTECH, SURFTECH, SUBTECH and SSG to refine the Naval opportunities
- Specific projects to move into technology
  - Insensitive / high performance munitions – ONR / NRL / NSWC-IH
  - VMRAM – take NRL / ONR / DARPA program to 10 Gigabit.
  - Ceramic nanocrystal optical substrates – NRL ARI/ ONR program / NAWC-CL
  - Lab on Chip – NRL / ONR / NSWC Dahlgren for CB detection
  - Distributed Autonomous Sensors (DAS) – build on ONR Grand Challenge
- ILIR/IAR as mechanism to accelerate exploitation of nanoscience by warfare centers.
- Use the NSF-Navy Civilian Service Fellowship-Scholarship program to enhance trained manpower replenishment (http://www.nsf.gov/pubs/2004/nsf0427/nsf0427.pdf)
- Work with the Navy MANTECH / SBIR programs to accelerate commercial viability.

NNI - A Challenge in Strategic Planning

2000 – 2005 Birth of the NNI

~ $200M/yr US Federal S&T
7 Federal Agency IWGN
US/German Funded Initiatives
Rapidly Growing Nanosciene Proposal Pressure

2005 – 2010 Transition into adolescence

~ $1B/yr US Federal S&T funding ~= Industrial R&D
~ 20 US State/Local/Start-up initiatives
Health/Environment Impact S&T
Need for Metrics & report cards
Building Blocks / Manufacturing / Metrology

2010 – 2015 The Teen Years -Increasing sophistication/complexity

Industrial R&D > Federal S&T
~$500B/yr market for products enabled by"Nano inside"
Specific Health/Environmental Regulations based on science
Growing workforce needs for specialized training/education
Directed self-assembly

2015 – 2020 The Young Adult – Moving toward maturity

Industrial R&D >> Federal S&T
>$1T/yr market enabled for "Nano inside"
Accepted degree programs in nanotechnology
"Aldrich" catalog of nanostructures
Directed, hierarchical self-assembly

New Weapons for New Wars

NANOTECHNOLOGY AND HOMELAND SECURITY

ON THE FASTRACK BILL HOLBROOK

DANIEL RATNER • MARK A. RATNER

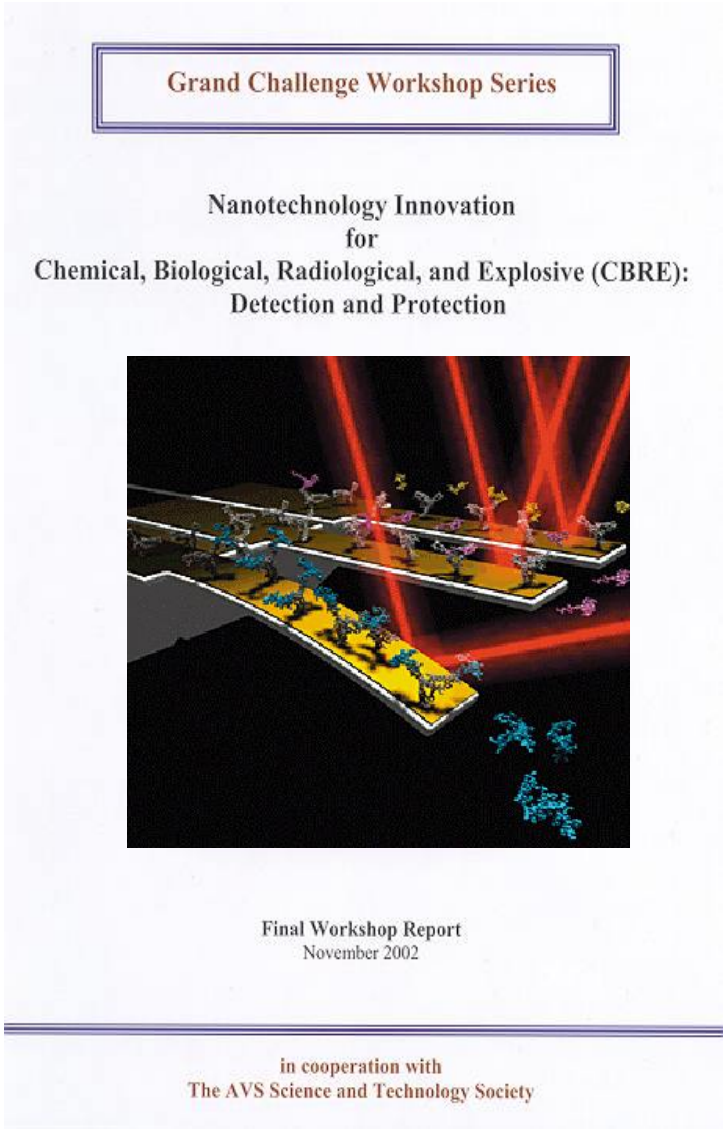
US: NATIONAL NANOTECHNOLOGY INITIATIVE (NNI) PROGRAM ($M)

		FY01	FY02	FY03	FY04
KNOWLEDGE GENERATION		**150**	**215**	**278**	
GRAND CHALLENGES		**150**	**325**	**303**	
NANOSTRUCTURED MATERIALS BY DESIGN	**NSF**		**~55**	**~65**	
NANOELEC, PHOTONIC, MAGNETIC	**DOD**		**~135**	**~105**	
ADVANCED HEALTHCARE/THERAPEUTICS	**NIH**		**~40**	**~40**	
ENVIRONMENTAL IMPROVEMENT	**EPA**		**~10**	**~10**	
ENERGY CONVERSION/STORAGE	**DOE**		**~10**	**~10**	
MICROCRAFT & ROBOTICS	**NASA**		**~5**	**~5**	
CBRE PROTECTION/DETECTION	**DOD**		**~20**	**~20**	
INSTRUMENTATION & METROLOGY	**NIST**		**~40**	**~35**	
MANUFACTURING SCIENCE	**NSF**		**~10**	**~10**	
CENTERS/NETWORKS		**70**	**90**	**106**	
INFRASTRUCTURE		**80**	**50**	**145**	
ETHICAL/SOCIAL IMPLICATIONS		**14**	**15**	**19**	
TOTALS		**464**	**~700**	**~850**	**~950**

DoD Programs in Nanotechnology

- Army
  Nanostructured polymers, quantum dots for IR sensing, nanoengineered clusters, nano-composites, Institute for Soldier Nanotechnology (ISN)
- Navy
  Nanoelectronics, nanowires and carbon nanotubes, nanostructured materials, ultrafine and thermal barrier nanocoatings, nanobio-materials and processes, nanomagnetics and non-volatile memories, IR transparent nanomaterials, NRL Nanoscience Institute
- Air Force
  Nanostructure devices, nanomaterials by design, nano-bio interfaces, polymer nanocomposites, hybrid inorganic/organic nanomaterials, nanosensors for aerospace applications, nano-energetic particles for explosives and propulsion
- DARPA
  Bio-molecular microsystems, metamaterials, molecular electronics, spin electronics, quantum information sciences, nanoscale mechanical arrays
- MDA
  Budding interest as science matures
- SBIR
  Nanotechnologies, quantum devices, bio-chem decontamination
- MANTECH
- OSD
  Multidisciplinary University Research Initiative (MURI), DEPSCoR, NDSEG

NNI Grand Challenge Workshop



Nanotechnology Innovation

For

Chemical, Biological, Radiological and Explosive: Detection and Protection

Sensing

- Unparalleled sensitivity
- Array based selectivity

Protection

- High surface area materials
- Nanoporous separation

Decontamination

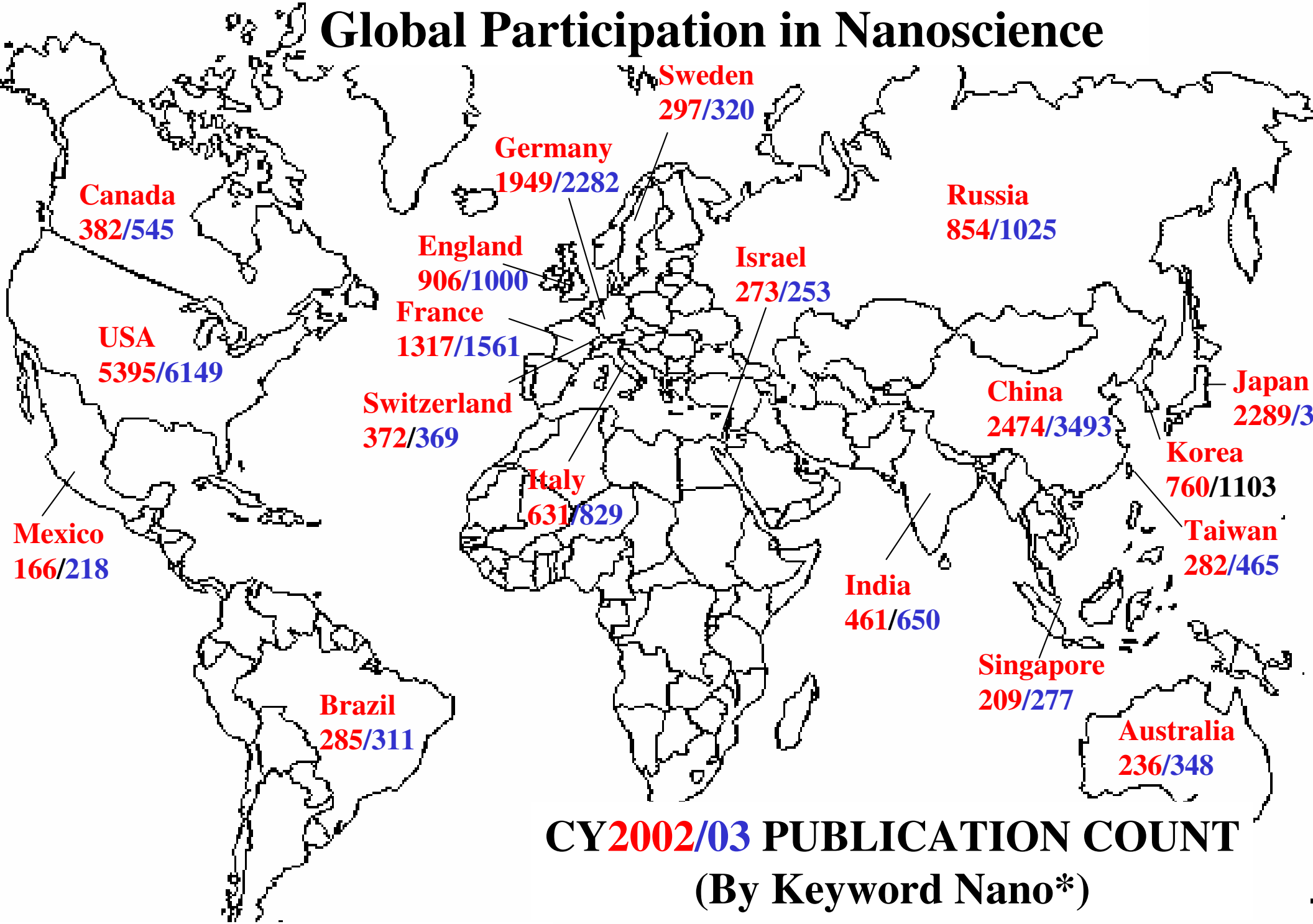
- Highly reactive, catalytic nanostructures

Therapeutics

- Prophylactic nanostructures
- Biological disruption

http://www.wtec.org/nanoreports/cbre/

Global Participation in Nanoscience



CY2002/03 PUBLICATION COUNT
(By Keyword Nano*)

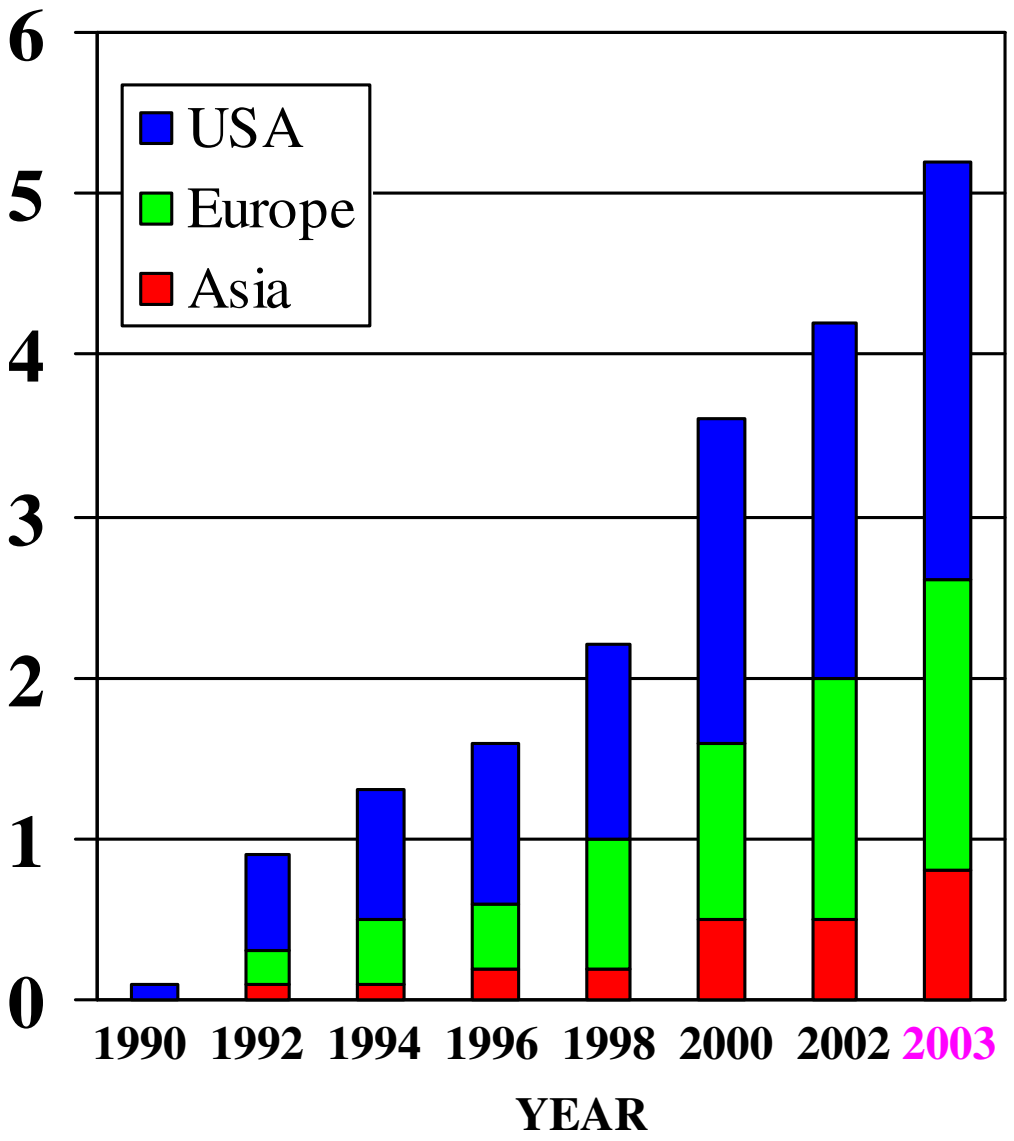
Science Citation Index of 5300 Journals

Total Worldwide- **18539 /24208**

Journal ISI Impact Factors (2001)

Nature	27.9
Science	23.3
Phys Rev Lett	6.6
Appl Phys Lett	3.8
Prog Polym Sci	3.7
Macromolecules	3.7
Chem Matl	3.6
J Phys Chem B	3.3
J Chem Phys	3.1
Phys Rev B	3.0
Phys Rev A	2.8
J Matl Chem	2.7
Chem Phys Lett	2.3

Percentage of "Nano*" Articles in Nature/Science/PRL

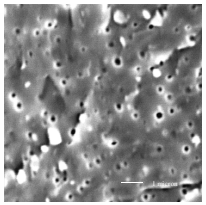


NanoMaterials Technology Success Stories

Nanostructured Dendritic Polymers

1998: Army Applications Successfully Demonstrated

Structural Polymers/ Composites ARL/UD



1999: Toughened Resins For composite armor (ARL/UD/AP)

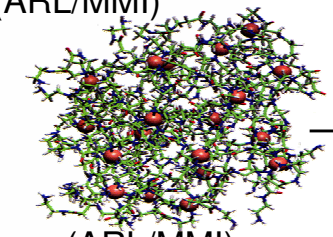
1999/2000: Toughened e-beam resins (ARL/Drexel/Northrup)

ARL Dendrimer Center of Excellence (1997)

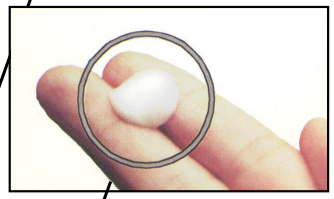
Multifunctional Coatings ARL/TDA

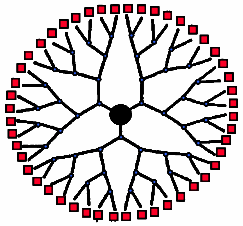
1999 Reactive additve For chemical warfare Resistant coatings (ARL/TDE/SW)

BioMedical (ARL/MMI)

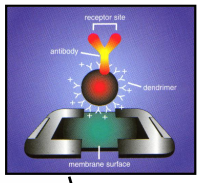


2001Self-dcon Skin Cream Trials (ARL/MCRID)

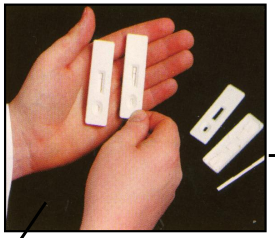




BioSensors (ARL/MMI)



2000 Joint Field Trials ALERT Ticket Biosensor ARL/SBCCOM/JPO



Synthesis of Dendrimers Tomalia (1984).

ANP, Inc.
ARL Spin-off
(2002)

1 2 3 4 5 6 7 8 9

TRL Levels with Time